FARMERS' BULLETIN 1047
UNITED STATES DEPARTMENT OF AGRICULTURE

DRY FARMING FOR BETTER WHEAT YIELDS

THE COLUMBIA AND SNAKE RIVER BASINS

THIS BULLETIN deals in particular with the dry-farming methods practiced on grain farms in the Pacific Northwest where the rainfall is less than 18 to 20 inches annually, but it also contains advice helpful to all farmers of that region who practice summer-fallowing.

Its purpose is to show the possibility of increasing crop yields in the dry-farming areas by using improved methods, and to discuss the practices which have been found most advantageous.

The summer fallow is a feature inseparable from all these methods. Experiment-station investigations, conducted for six years continuously under average dry-farming conditions, show that the highest yields have been secured by plowing early, and thoroughly cultivating the summer fallow.

The purposes of summer-fallowing and details of the methods of their accomplishment are presented, with the application of these methods to the cultivation of "blow" soils and "nonblow" soils, and methods are suggested for preventing and stopping the blowing of soils.

Attention is given to the seeding of winter and of spring wheat, and suggestions are made for properly maintaining the organic matter in the soil.

Office of the Secretary
Contribution from the Office of Farm Management
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Washington, D. C. July, 1919

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DRY-FARMING DISTRICTS IN THE PACIFIC NORTHWEST.

IN THE Pacific Northwest are two general dry-farming districts—the Columbia River Basin and the Snake River Basin. (See the shaded area in the accompanying map.) Dry farming has been carried on extensively in the Columbia River Basin for more than 30 years. During this time the practice of summer-fallowing the land every other year has become very general in all localities having an average annual precipitation of less than 18 to 20 inches. That is, the land is clean-cultivated as fallow one year, and produces a crop of grain, usually wheat, the next year. In the more humid districts the land may be summer-fallowed once in 2 years, once in 3 years, or once in 4 years.

In the Snake River Basin, on the other hand, dry farming is not so well established. While a limited amount of nonirrigated farming has been carried on in the upper Snake River Valley for a number of years, thousands of acres of dry sagebrush land have been

[1] Acknowledgments are due numerous farmers who kindly furnished the information forming the basis of this bulletin. Also to M. A. McCall, D. E. Stephens, and A. C. Aleher, superintendents, respectively, of the Bureau of Plant Industry Cooperative Experiment Stations at Lind, Wash., Moro, Oreg., and Aberdeen, Idaho, for helpful suggestions given in assembling the material for this bulletin.

cleared and brought into cultivation very recently. Summer-fallowing is also practiced very generally in the Snake River Basin.

This Bulletin is based (1) on an extensive study of the methods practiced under dry-farming conditions in the Columbia and Snake River Basins, and (2) on the investigational work done by the experiment stations of Idaho, Oregon, and Washington. The purpose of the bulletin is (1) to show the possibility of increasing the yield of wheat per acre, and (2) to discuss the cultural methods which, according to farm experience and experimental data, give the highest yields. While the bulletin is intended primarily for districts having an annual precipitation of less than approximately 18 inches, it will be helpful also to farmers of the Pacific Northwest who summer-fallow under a greater rainfall than 18 inches.

DESCRIPTION OF THE REGION.

Dry farming is practiced under a wide range of conditions in the Pacific Northwest. In the Columbia River Basin the altitude at which dry farming is carried on varies from approximately 600 feet to 3,000 feet, and in the Snake River Basin from 2,100 feet to 6,500 feet. This causes a great difference in the length of the growing seasons in the various localities.

The climate is marked by a wet and a dry season and a limited rainfall. The wet season comes during the winter, and the dry season during the summer, July and August being extremely dry. One of the chief difficulties in raising winter wheat is the lack of sufficient autumn rains to germinate the seed and get the crop started before the beginning of winter. Torrential rains seldom occur, and very little water is lost by surface run-off except when rain falls or a snow melts suddenly upon a frozen surface.

The types of soil used for dry farming vary from heavy silt loams to very fine sand and sandy loams. The prevailing soil type is silt loam. These soils are usually very well supplied with the mineral plant-food elements, especially with potash and phosphorus. On the other hand, the supply of organic matter and nitrogen is generally low. In some localities where the rainfall is scant, much damage is frequently done during the spring and summer by the wind blowing and drifting the soil. (See fig. 8.) The soils that blow and drift require special tillage methods to control them, and are spoken of locally as "blow" soils. For these reasons and for convenience in discussing the cultural methods practiced, the soils are here classified as "blow" soils and "nonblow" soils. The soils that blow constitute a very small part of the total area dry-farmed.

POSSIBILITIES OF INCREASING WHEAT YIELDS.

A comparative study of the tillage methods practiced and the yields secured on individual farms invariably leads to the con-

clusion that the yield of wheat per acre can be increased greatly by performing the cultural operations when they will be most effective. The results obtained at the experiment stations previously mentioned also lead to the same conclusion.

The table below presents this matter in concrete form. It shows the possibility of increasing wheat yields under strictly dry-farming conditions. The yields given in the table are 6-year averages for Turkey winter wheat grown on land summer-fallowed by different methods at the dry-farming experiment station at Moro, Oreg.

This station is operated under an average annual precipitation of 11.6 inches, the average for the years 1905 to 1916 inclusive. The lowest annual rainfall during this period was 7.68 inches and the highest 14.68 inches. The soil of the station farm is a silt loam that is not subject to blowing and drifting. The elevation of the farm is approximately 1,800 feet.

FIG. 1.—Good plowing for nonblow soils. The plow that turned this soil was equipped with a combination rolling coulter and jointer and a rod for turning under the stubble. If the stubble and trash are well covered, the tillage implements slip through the soil more freely.

Six-year average yields of Turkey winter wheat grown on land summer-fallowed by different methods at the Sherman County Branch Experiment Station, Moro, Oreg., 1913 to 1918, inclusive.

[Bushels per acre.]

Time of plowing.	Method 1: No cultivation after plowing.	Method 2: Harrowed once after plowing.	Method 3: Thorough cultivation after plowing.
Apr. 1...	24.8	26.7	30.5
May 1...	24.5	25.4	26.4
June 1...	22.5	22.4	22.5

NOTE.—From Table XXVIII, Oreg. Exp. Sta. Bul. No. 144, with added unpublished data for the years 1917 and 1918. The Sherman County Branch Experiment Station is operated cooperatively by the Oregon Agricultural Experiment Station and the Office of Cereal Investigation, U. S. Department of Agriculture.

PRACTICES IN THE DIFFERENT SUMMER-FALLOW METHODS.

In summer-fallowing by the three methods given in the table on page 5, the land is plowed at three different dates, April 1, May 1, and June 1. In each case plowing is the first tillage operation performed. The essential features of the three methods of summer-fallowing are as follows:

Method 1.—The aim of the first method is to give no cultivation after the land is plowed. Any weeds that appear are allowed to grow. To keep the land from becoming foul the weeds are removed with a hoe, disk harrow, or knife weeder just before they form seed.

Method 2.—The second method represents very lightly cultivated summer fallow. Under this method the land is harrowed once immediately (the same day) after it is plowed. No further cultivation is then given except to remove the weeds just before they form seed, as described under the first method.

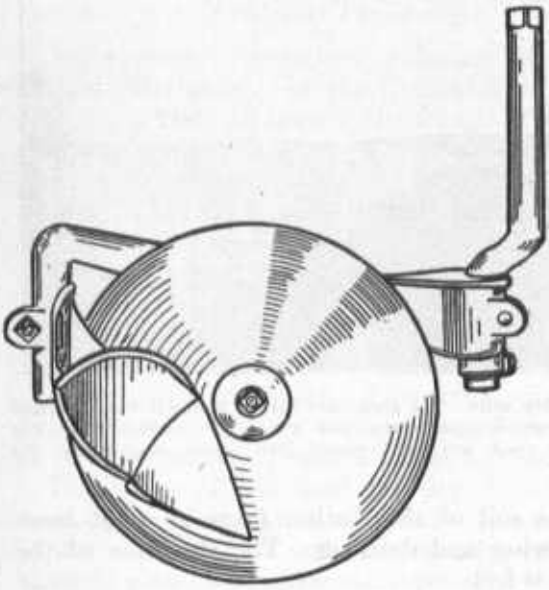

FIG. 2.—A combination rolling coulter and jointer that is attached to the plow beam to assist in turning under heavy stubble.

Method 3.—The third method represents thoroughly cultivated summer fallow. The land is harrowed twice immediately after it is plowed. As soon as the weeds appear, usually in about 3 weeks, it is harrowed again. Sufficient cultivation is then given to keep the land free from weeds. The land plowed April 1 and May 1 usually requires two, and sometimes three, cultivations. As few weeds grow on the land plowed as late as June 1, the usual cultivation given in this case is to harrow twice after plowing.

RESULTS FROM DIFFERENT SUMMER-FALLOW METHODS.

From a study of the above table it will be observed:

1. That early plowing under each of the three methods of summer-fallowing gave higher yields than late plowing. Under the first method, where no cultivation is given, plowing April 1 gave an

increased yield of 10 per cent over plowing June 1. Under the third method, where thorough cultivation was given, the increased yield from land plowed April 1 was 8 bushels per acre, or 35½ per cent above that plowed June 1.

2. That thorough cultivation of land plowed April 1 increased the yield of wheat per acre from 24.8 bushels to 30.5 bushels. This is an increase of 23 per cent.

3. That the cultivation of land plowed June 1 neither increased nor decreased the yield of wheat. Should enough late rains come to start a crop of weeds after the land is plowed, cultivation would doubtless be beneficial.

It will thus be seen that the highest yields were secured by plowing early, and thoroughly cultivating the summer fallow. The significance of the possibility of increasing yields by this means should be apparent when it is remembered that much of the land summer-fallowed each year is plowed late in the season—i. e., just before harvest. There are two reasons why so much late plowing is done. In the first place, the equipment of many farms is not sufficient to do the work in good season. In the second place, much less work is necessary to control the weeds on late plowing than on early plowing. While most farmers appreciate the advantage of early work, some still prefer to plow late in order to avoid as much cultivation as possible.

PURPOSES OF SUMMER-FALLOWING.

In order to return maximum yields, three primary purposes should be accomplished by summer-fallowing—namely, (1) the preparation of a suitable seed bed for the sowing of winter wheat, (2) the conservation of soil moisture for the use of the future crop, and (3) putting the soil into condition to produce a satisfactory crop.

THE PREPARATION OF A SUITABLE SEED BED FOR SOWING WINTER WHEAT.

When satisfactory stands are secured, winter wheat yields from 20 to 25 per cent more than spring wheat. For this reason the summer-fallowing should be done with a view to growing winter wheat. When autumn rains are abundant, good stands of winter wheat may be obtained on almost any kind of summer fallow. On the other hand, when autumn rains are scant it is much easier to start winter wheat on early plowed and well-tilled fallow than on land that is plowed late in the season and left rough as the soil comes from the plow. One of the chief purposes of summer-fallowing, then, should be the preparation of a seed bed that will make the sowing of winter wheat as nearly independent of the autumn rains as is possible.

THE CONSERVATION OF SOIL MOISTURE FOR THE USE OF A FUTURE CROP.

Soil moisture is lost during the spring, summer, and autumn months of the summer-fallow season in two ways: (1) It evaporates from the surface of the ground, and (2) it is used in large quantities by weeds when allowed to grow. Evaporation begins in the early spring when the surface of the ground begins to dry, and continues (more or less) throughout the season. Weeds begin to use soil moisture with the germination of the seed from which they spring, and the quantity used increases with the growth of the plants. Evaporation affects the moisture chiefly at or near the surface of

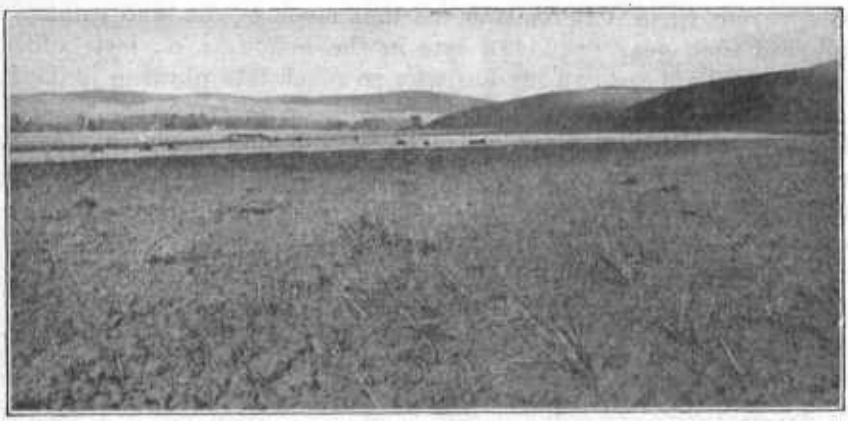

FIG. 3.—Poor plowing for nonblow soils. It might be considered good plowing for soils that blow where it is desirable to have the stubble mixed with the surface soil. The stubble in the surface soil gives much trouble by clogging the knives of such weeders as are shown in figs. 4 and 5.

the ground, while weeds, through their root systems, use the moisture from below the surface. For this reason far more attention should be given to keeping the land free from weeds than to maintaining a loose soil mulch for reducing evaporation.

Since the late spring and summer rains are seldom sufficient to penetrate the soil more than a few inches, summer-fallow tillage is employed to conserve the moisture already in the soil when spring opens, rather than to store the summer rains. In this way at least a portion of one winter's precipitation is carried over for use of the crop the second year.

PUTTING THE SOIL INTO CONDITION TO PRODUCE A SATISFACTORY CROP.

When questioned as to why they summer-fallow, observing farmers usually give the following reasons: (1) To conserve moisture, (2) to destroy weeds, and (3) to put the soil into such condition that it will

produce satisfactory crops. That is, the farmer well understands that while the land is being summer-fallowed, certain changes take place within the soil that give it renewed fertility. As to just what these changes are and how they take place there is yet much to learn.

It is reasonably certain, however, that the renewed productiveness is chiefly brought about through the decay of the vegetable matter of the soil. In order to cause the maximum decay to take place, the stubble and other vegetable matter must be incorporated with the soil in the early spring while the ground is yet moist, for moisture is very essential to decay. After the vegetable matter has been plowed under or mixed with the surface soil, it is necessary to do enough cultivation to keep the land free from weeds, If allowed to grow, weeds use the moisture that is so necessary to decay.

SUMMER-FALLOWING NONBLOW SOILS.

The soils classified here as nonblow soils vary widely. In the drier localities, they grade insensibly into the soils that do blow. In the more humid districts, they are heavy silt loams that receive sufficient precipitation to saturate them practically every winter. On the one extreme, some attention must be given to the possibility of the soil blowing. On the other extreme, this question receives no consideration whatever.

Summer-fallowing is a loosely used term. With many farmers it means plowing the land to be fallowed, regardless of any other tillage operations that may be performed, either before or after the land is plowed. We frequently hear farmers say they are "Through summer-fallowing" when they have finished plowing. As used in this discussion the term "summer-fallowing" includes all of the tillage operations performed during the fallow year, plowing being only one of these operations.

The soil conditions and the annual and monthly rainfall vary too widely in the Columbia and Snake River Basins to permit laying down uniform directions for handling the land to be summer-fallowed. For this reason no attempt is made in the following pages to say definitely what tillage operations should be performed. It is safe to say that no one as yet has this information. An attempt is made, however, to discuss the methods that, according to the experience of the very successful farmers, are giving the most profitable returns. As the season varies the tillage operations vary. The farm operator should have definitely in mind the principal objects to be accomplished by summer-fallowing. With these objects in view, and with the equipment at his disposal, he should perform such tillage operations as will best accomplish the desired results.

The following are some of the more satisfactory methods of summer-fallowing soils that are not subject to blowing:

EARLY SPRING PLOWING.

This method of summer-fallowing is used more extensively than any other. When plowing is the first operation performed it should be done in the early spring while the soil is yet moist. In most localities the soil remains in fairly good condition for plowing from 30 to 40 days after spring opens. In order to form a good winter-wheat seed bed, in which the moisture remains at a uniform depth below the surface, it is necessary to harrow most soils twice soon after being plowed. The first harrowing is frequently done by hitching a spike-tooth harrow behind a gang plow. The second harrowing is

FIG. 4.—A common sled knife weeder, locally called a "slicker." This implement is used to destroy weeds growing on the summer fallow. The driver rides on the sled, and the knife runs 3 to 4 inches below the surface of the ground.

then done as soon as the plowing has been completed. On the heavier soils, the spike-tooth harrow is frequently used a third and even a fourth time, to settle the soil further and destroy weeds.

On the lighter soils, which are likely to become too finely pulverized by much cultivation, many farmers prefer to delay the first harrowing for a few days after the land is plowed in order to let the clods dry and harden, and also to let a crop of weeds start. In this case the land is harrowed when the weeds are white in the soil or just as they are coming through the surface of the ground. Enough subsequent cultivation is then given to keep the land free from weeds. Some form of knife weeder is generally used on the heavier soils, and the rod weeder on the light soils. (See figs. 4, 5, 13, 14, 15, and 16.

EARLY SPRING DISKING BEFORE PLOWING.

Many farmers prefer to double-disk the stubble land before it is plowed for summer fallow. The disking is done in the early spring or as soon as the seeding of spring grain has been finished. By destroying a crop of weeds and forming a loose surface mulch (see fig. 7), the disking causes the soil to remain in good condition for plowing several weeks longer than it otherwise would.

In some cases the land is double-disked twice before it is plowed, the last disking being done after a second crop of weeds has started. The object in disking twice is to throw the plowing so late that no weed seed will then germinate.

In most instances, however, the land is double-disked but once. The disking should be done before the weeds and volunteer grain in the stubble have made much growth. Likewise the plowing should

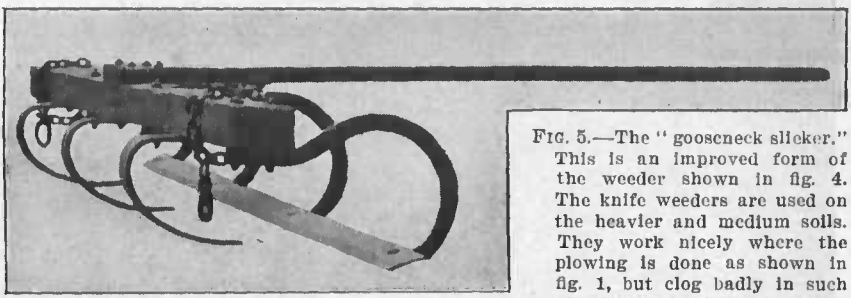

FIG. 5.—The "gooseneck slicker." This is an improved form of the weeder shown in fig. 4. The knife weeders are used on the heavier and medium soils. They work nicely where the plowing is done as shown in fig. 1, but clog badly in such plowing as is shown in fig. 3. The driver rides on the tailboard projecting behind and the team is hitched to the chains around the beam. When the knife clogs the team is stopped and the knife raised out of the ground by lifting up the tailboard.

be finished before the second crop of weeds has become large enough to draw seriously on the soil moisture. After the land is plowed it should be kept free from weeds.

This method of summer-fallowing is to be recommended (1) if there is a heavy stubble or other trash to be plowed under, and (2) if the land can not be plowed until late in the season. A thorough disking before plowing chops up the stubble, mixes it with the surface soil, and prevents it from going into the bottom of the furrow in a mat. The early disking also materially lessens the draft of the plow, causes the soil to be more mellow and freer from clods when plowed, and lengthens the plowing season from 4 to 6 weeks.

DRY PLOWING IMMEDIATELY AFTER HARVEST.

Dry plowing immediately after harvest is practiced in certain localities where the rainfall is scant and where the Russian thistle grows profusely in the stubble after the wheat is harvested. If the thistles are allowed to mature they form such a stiff, dense mat on

the surface of the ground that it is necessary to remove them the following spring in order to be able to plow. This is usually done by burning the field over in the early spring, a practice injurious to the soil, since practically all surface vegetable matter is consumed. (See fig. 18.)

To be effective, the plowing must be done as soon as possible after the wheat is cut, the chief object being to turn the thistles under while they are yet green and before they have matured seed. For this reason, wheat hauling must be postponed until after the plowing is done. The land plowed at this time is left rough over winter just as it comes from the plow. In the early spring a mulch 4 or 5 inches

FIG. 6.—An 8-mule harrow team. The driver rides a saddle horse. The harrow is used soon after plowing to settle the soil, fill up the air cavities, and make the soil uniform and compact. It is an excellent implement with which to destroy weeds when they are very small. This particular team is harrowing winter wheat in the early spring.

deep is formed with a spring-tooth or disk harrow. Without replowing, sufficient cultivation is then given to keep the land free from weeds.

This method has the following advantages: (1) The Russian thistles are turned under while they are yet green and before they have matured seed. (2) The soil moisture and plant food necessary to mature the thistles are conserved for the future wheat crop. (3) The necessity of burning the stubble and weeds is obviated. (4) By plowing a portion of the land as soon as the grain is cut it is possible to finish plowing the remainder of the land to be summer-fallowed at a much earlier date the following spring.

Farmers who dry-plow immediately after harvest contend that this method gives even better yields than early spring plowing. The method has two disadvantages: (1) It destroys the stubble pasture.

(Since most of the farming is done with horses and mules, this is an important item. It must be remembered, however, that only a portion of the land can be handled by this method, hence only a part of the pasture is destroyed.) (2) It is more expensive to plow when the soil is dry than when it is moist. The plow shares must be sharpened frequently and the draft of the plow is heavier.

RIGHT-LAP PLOWING OR DOUBLE DISKING IMMEDIATELY AFTER HARVEST.

The chief object of this method also is to destroy the Russian thistles in the stubble as soon as possible after the grain is cut. While not as effective as ordinary plowing, right-lap plowing (see fig. 11) or double disking just after the grain is cut usually holds the thistles in check sufficiently to make it unnecessary to burn the weeds

FIG. 7.—A 6-horse team disking stubble before it is plowed.

the following spring in order to plow. Land that has been treated in this way may be summer-fallowed the following season by again disking or right-lapping once or twice, and then controlling the weeds with a rod weeder. Or, the land may be handled by either the first or second method discussed above.

A COMBINATION OF METHODS.

If the area to be summer-fallowed is greater than can be handled efficiently by any one method, a combination of methods should be used in order to get the work done in good season. The first two methods described above are frequently used on the same farm. In this case about half of the land to be fallowed is disked as early as possible in the spring. The undisked land is then plowed first

and the disked portion last. If the work can not be finished in good season by this combination, a portion of the land should be plowed just after harvest or during the fall and early winter. Dry September plowing at the experiment station at Moro, Oreg., has given yields about equal to plowing May 1, with thorough cultivation.

SUMMER-FALLOWING BLOW SOILS.

In addition to preparing a suitable seed bed, conserving moisture, and getting the land into condition to produce a profitable crop, soils that are subject to blowing and drifting should also be handled with a view to (1) leaving the stubble and trash on or mixed with the surface soil, (2) making enough clods to cover the surface of the ground, and (3) rubbing and pulverizing the soils just as little

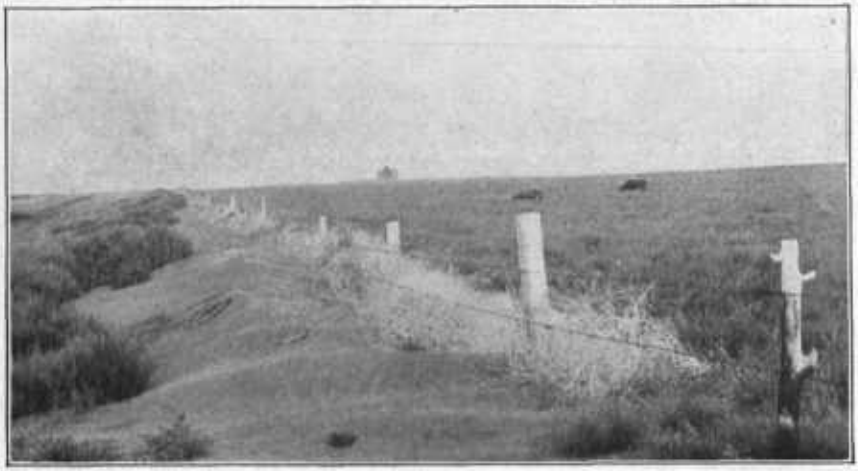

FIG. 8.—A sand dune that was blown into the lane from the field to the right. The weeds along the wire fence stopped the sand.

as possible. Stubble, trash, and clods on the surface of the ground tend to keep the soil from blowing, while pulverizing the soil tends to make it more subject to blowing. The tillage that should be given or the methods followed depend upon the conditions to be met. The presence of Russian thistles in the stubble, for example, greatly modifies the tillage operations that should be performed. To farm successfully soils that blow, requires the best of judgment, and frequently very prompt action. The aim should be to prevent the soil from blowing at all. If a blow begins, however, prompt action should be taken to stop it. In the past, blow soils have been summer-fallowed by very much the same methods as are used for light soils that do not blow. This has frequently resulted in disaster. Public sentiment should demand that safer methods be used.

DRY PLOWING IMMEDIATELY AFTER HARVEST WITH THE MOLDBOARDS OF THE PLOW REMOVED.

This method differs from the one discussed above under the caption, "Dry plowing immediately after harvest," in that the plowing is done, in this case, with the moldboards of the plow removed. (See figs. 9 and 10.) Plowing at this time destroys the Russian thistles before they have matured seed. The purpose of removing the moldboards of the plow is to leave the stubble and weeds on the surface of the ground so that the soil will not blow. As soon as the frost is out of the ground the following spring, a mulch is formed with either the spring-tooth harrow, the disk harrow, or the right-lap plow. The mulch is formed in the early spring while the soil is wet,

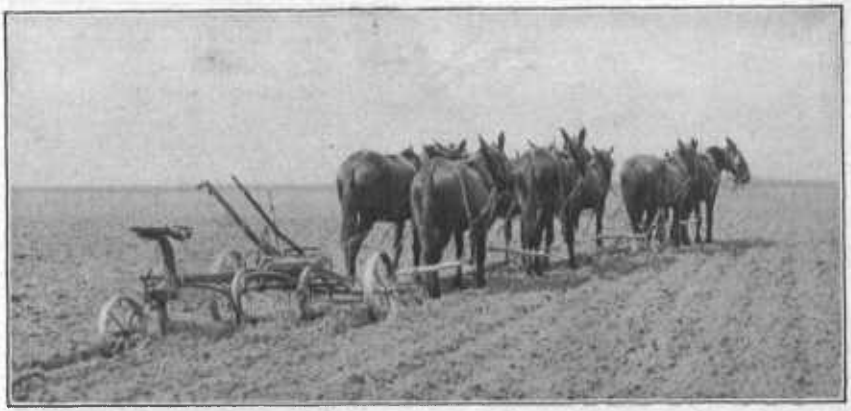

FIG. 9.—An 8-mule team plowing blow soil with the moldboards of the gang plow removed. This land was double disked in the early spring and then plowed when the weeds began to appear. Plowing in this way makes clods and leaves the trash on the surface. This is one of the safest ways of handling blow soils.

in order to make clods. After the surface mulch is formed the weeds are usually controlled with the rod weeder.

RIGHT-LAP PLOWING OR DOUBLE-DISKING IMMEDIATELY AFTER HARVEST.

This method is identical with that discussed above under the same caption. It is repeated here to emphasize the fact that it is well suited to soils that are subject to blowing and which are infested with Russian thistles.

EARLY SPRING DISKING AND PLOWING WITH THE MOLDBOARDS OF THE GANG PLOW REMOVED.

This method is suited to land that is not badly infested with thistles. The land is first double-disked in the early spring to destroy weeds and mix the stubble with the surface soil. When a crop

of weeds has started, it is then plowed with the moldboards of the plow removed. The plow is run about 4 to 5 inches deep; just deep enough to do a good job and form the desired mulch. Weeds are then controlled with a rod weeder, the rod being run under the entire mulch.

SUMMER-FALLOWING WITH THE RIGHT-LAP PLOW.

The right-lap plow is used in summer-fallowing both blow and nonblow soils on which a crop of Russian thistles has been permitted to develop in the stubble the previous summer and autumn. In some instances the growth of the thistles may be so dense as to clog the plow, in which case the only thing that can be done is to remove the

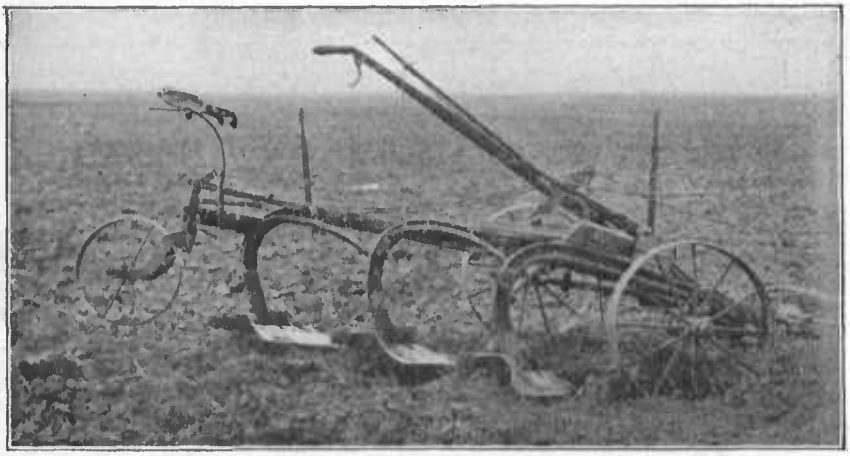

FIG. 10.—The three-bottom gang plow shown in fig. 9. The plows are lifted out of the ground to show the shares with the moldboards removed.

weeds from the field. Generally the disks of the plow will run over and chop up the thistles. When this method is used the land to be summer-fallowed is cultivated with the right-lap plow in the early spring as soon as a crop of weeds has started. If there are but few weeds on the land the first plowing may be deep enough to form the desired mulch. If, on the other hand, there are many weeds, it is usually necessary to plow twice. After forming a mulch about 5 inches deep the weeds are then usually controlled with the rod weeder. This method is used only in the drier districts which are infested with the Russian thistle.

SUMMER-FALLOWING WITH THE DISK HARROW.

In the drier districts, land that is subject to blowing frequently is summer-fallowed by disking from two to three times during the spring and early summer. Some double-disk, while others prefer to

single-disk in order to pulverize the soil as little as possible. The first disking is done in the early spring, and the second and third as successive crops of weeds appear. One of the advantages of this method is the large acreage that may be handled with a given force. One man with a large disk-harrow and 10 to 12 good mules can disk about 20 acres per day. In 40 days 400 acres can be covered twice.

SUGGESTIONS FOR PREVENTING THE BLOWING OF SOILS NOT BEING SUMMER-FALLOWED.

A hoe drill should be used when possible in seeding land that is liable to blow. The seeding should be the last operation, and the drill should be driven at right angles to the direction of the prevailing wind. The hoes of the drill ridge the surface and raise clods to

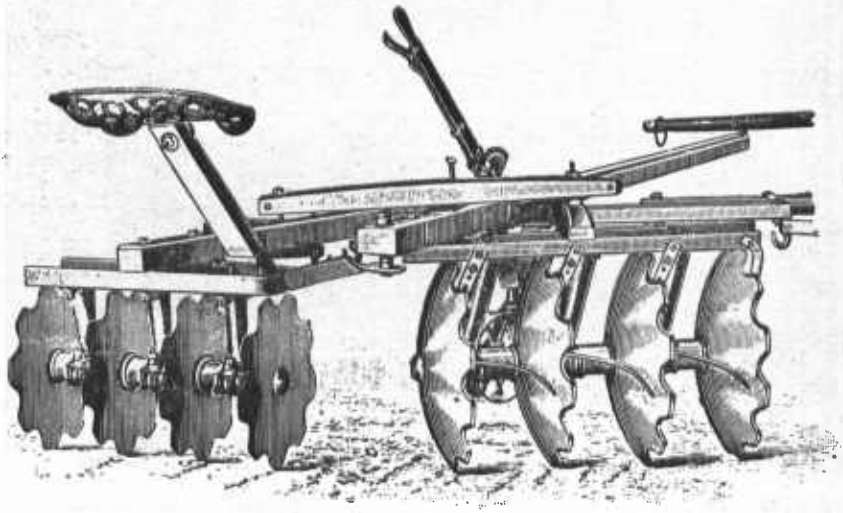

FIG. 11.—The right-lap plow, also called the "right-lap" and "right-harrow." This plow turns the soil over more completely than a disk harrow, but not so completely as a disk plow. It is an excellent implement with which to plow land that is infested with Russian thistles.

the surface. The ridges tend to hold the fine particles of the soil until the wheat becomes established.

If land that is to be seeded to spring wheat is liable to blow, the surface soil may be puddled and a layer of clods formed by cultivation with a spike-tooth harrow, spring-tooth harrow, or shovel cultivator, in the early spring when the soil is wet. Such land may also be prevented from blowing by sowing the wheat with a hoe drill in the early morning when a crust is frozen on the surface of the ground. The hoes of the drill should be set as far ahead as possible, and the team driven slowly in order to give the drill a better chance to break up the frozen crust. The chunks of frozen soil make clods when they thaw and dry.

If land that is seeded to winter wheat is liable to blow, it may be treated in two ways: (1) If the wheat is well enough rooted to stand it, the land may be harrowed when wet in the early spring to puddle the surface soil and make clods. (2) If the wheat is not well enough rooted to stand the harrowing, the area that is liable to blow may be covered with straw or manure, preferably with a straw spreader or manure spreader.

Excellent results have been obtained in redeeming land that blows badly by growing rye and using it for pasture for 2 years. The rye may be sown on land that has been summer-fallowed, or it may be sown in the stubble and covered by disking during the fall or early winter. While the rye usually volunteers the second year when used

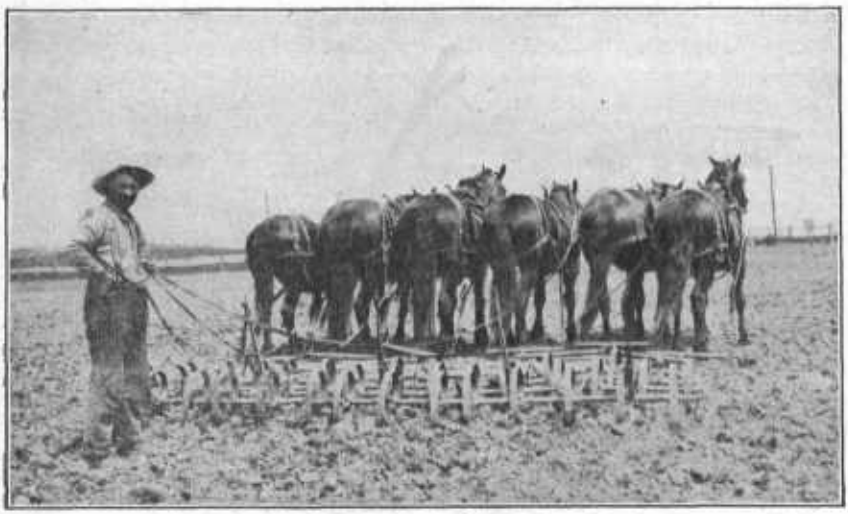

FIG. 12.—The spring-tooth harrow. An excellent implement to use instead of the spike-tooth harrow on soil that is inclined to blow. The spring-tooth harrow brings clods to the surface and leaves the trash there.

for pasture, seed may be sown in the fall and covered with the disk harrow. When used for pasture for 2 years, the soil usually becomes sufficiently packed to stand summer-fallowing again with but little danger of blowing.

SUGGESTIONS FOR STOPPING SOIL BLOWS.

If a soil once begins to blow the matter should receive prompt attention. When the blow begins the area affected usually is small, and prompt attention and a little work generally will stop it. A delay of a few hours or days may permit the area affected to spread until much damage is done, not only on the farm where it starts, but on neighboring farms as well.

One of the most effective ways of stopping a blow is to spread straw or manure over the affected area. This should be done as soon as the blow is discovered. Begin on the windy side of the area and work with the wind. The straw may be held in place by running a disk harrow over the area strawed, the disks of the harrow being set perfectly straight. Spreading straw or manure on the surface is about the only way of stopping a blow where the soil is pure sand.

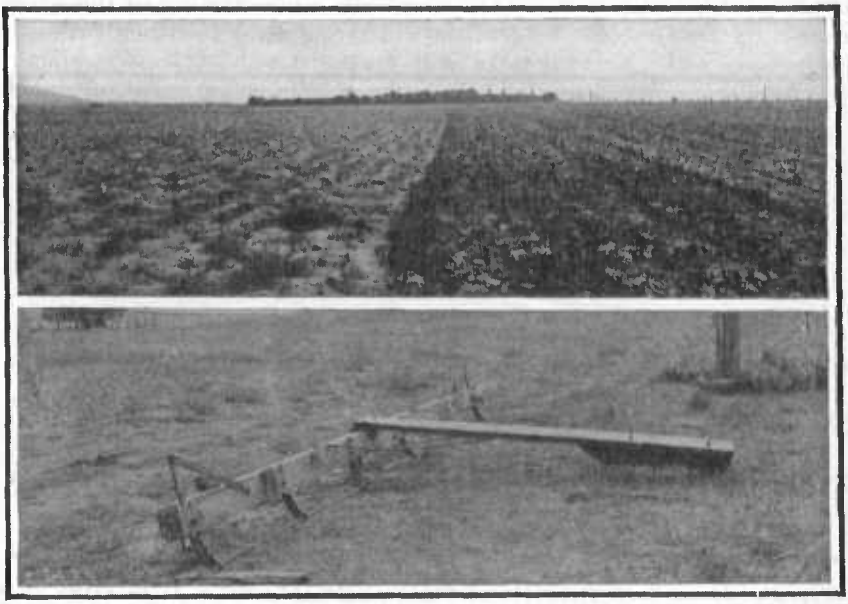

FIG. 13.—Above, work of the rod weeder on very light soil. The land to the right has been cultivated and that to the left has not. Note the clods on the surface of the area that was cultivated. Below, a single-rod weeder. The rod weeder is usually homemade, and for this reason the construction varies widely. It is used extensively on blow and lighter soils. The depth at which the rod runs is regulated by the position at which the driver stands on the tailboard. Some prefer to use a quarter-inch electric power line wire instead of the rod. In this case the wire passes up over the end of the 4 by 6 inch beam and is tightened by means of an eyebolt.

Blows usually may be controlled in the early stages of their development by cultivating with a spring-tooth harrow, shovel cultivator, or empty hoe drill. The implement should be driven at right angles to the direction of the prevailing wind in order to let the drifting sand fall into the furrows. If there are no clods to be brought to the surface, such cultivation will do little or no good.

Land that has been blowing for some time may be controlled or held in check by plowing furrows across the affected area at right angles to the direction of the prevailing wind. The furrows should be from 1 to 2 rods apart. The furrows catch the sand and keep it

from traveling on the surface of the ground. Furrows do little good if the soil is mostly sand.

SEEDING WINTER WHEAT.

In order to avoid the difficulty of harvesting wheat infested with "tumbling" or "Jim Hill" mustard, the seeding of winter wheat is generally postponed until sufficient autumn rains have fallen to start the mustard, and insure a stand of wheat. The seeding of the wheat is usually delayed for several days after a good rain has fallen to

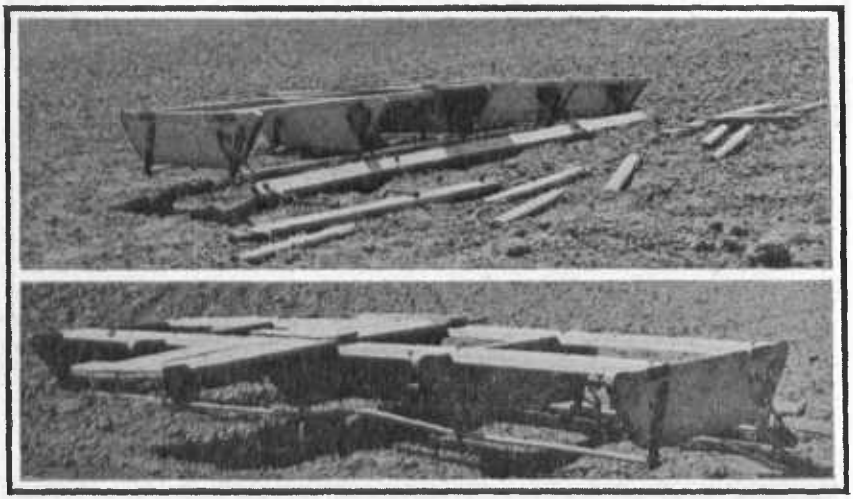

FIG. 14.—Above, front view of a stationary double-rod weeder, to be drawn by 6 horses. It is 12 feet long. The runners are 11 inches wide, 46 inches long on the top, and 31 inches long on the bottom. They are shod with iron or steel. The rods are 28 inches apart and are placed about 2 inches below the bottoms of the runners. Below, rear view of the same weeder. When the driver stands on the back end of the tailboard, which is the usual position, the back rod is in the ground. By quickly shifting his position to the front of the implement, and vice versa, the driver can dump or clean this implement without stopping or making skips. This is a distinct advantage over the single-rod weeder.

permit the mustard seed to germinate. The young mustard plants are then killed with a spike-tooth harrow or other suitable implement, and the wheat drilled immediately. If moisture conditions are favorable the seed should be sown from 1 to 2 inches deep. If the seeding is done late in the fall the seed should be sown very shallow. If another crop of weeds starts at the same time the wheat germinates the land may be harrowed again when the sprouts on the wheat kernels are not more than an inch long. If not enough rain comes to germinate the mustard and get the wheat started before cold weather sets in, the majority of farmers think it safer to grow spring wheat, in which case the summer fallow is seeded early the following spring.

Some very excellent results have been secured by seeding winter wheat late in August or early in September before the coming of the autumn rains. In order to obtain a satisfactory stand of winter wheat sown at this time, the summer fallow must be uniform, compact, and in excellent tilth. The moisture must not be over 3 or 4 inches below the surface, and the seed must be put down to moist soil. Very much better germination will be secured if the drill is provided with a press-wheel attachment. The press wheels pack the soil around the seed and cause it to absorb moisture and germinate quickly. Mustard does not start until after it rains. If a good stand of wheat can be started ahead of the mustard, the latter will be prevented from doing very much damage. In districts where the rainfall is lightest, it is seldom possible to conserve sufficient moisture to germinate wheat before the fall rains come.

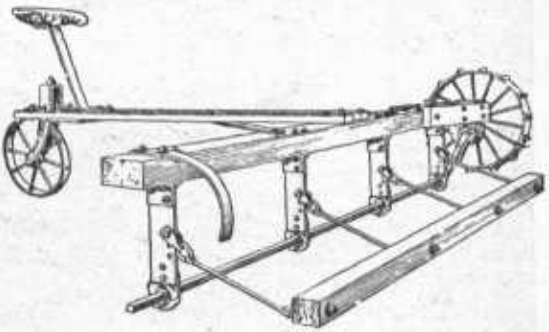

FIG. 15.—This is one type of a square revolving rod weeder. By means of a tumbling rod and two cogwheels, the square rods turn under the surface of the ground in the opposite direction to that of the drive wheel. The revolving of the rod prevents this weeder from clogging. For this reason it is one of the safest weeders to use on trashy blow soils. The draft of this implement is considerably greater than that of a stationary rod weeder.

SEEDING SPRING WHEAT.

Summer-fallow land should always be sown to winter wheat if sufficient rain comes to germinate the seed and get the wheat up in good season in the fall. If the seeding is delayed until spring it may be done by one of two methods:

1. With a hoe drill sow the wheat about 2 inches deep in the early spring as soon as the soil has warmed up and is in good working condition, drilling the wheat being the first operation performed. Give the field a thorough harrowing before the wheat has germinated sufficiently to be injured by such treatment. The hoe drill is preferred to the disk drill because the former cultivates the soil better. The disk drill does better than the hoe drill on very trashy land. The wheat is drilled before harrowing in order to get the seeding done early and to give the wheat the start of the weeds that may come later.

2. By the second method the land is harrowed thoroughly (about twice) before the grain is sown, and again once or twice after it is sown. In order to destroy all the weeds possible, the harrowing after seeding may be delayed until the sprouts on the wheat grains are about 1 inch long.

Whichever method is used it should be the aim to germinate and kill a crop of weeds at the time of seeding. If there are weeds that the drill and harrow will not destroy, a knife or rod weeder should be used before the seed is sown. In some instances the ground packs so firmly that it is necessary to form a surface mulch with the disk or spring-tooth harrow.

MAINTAINING THE ORGANIC MATTER OF THE SOIL.

The organic matter of the soil is being affected in two ways: Through the process of decay, on the one hand, it is gradually disappearing. By the addition of stubble, weeds, and the roots of both

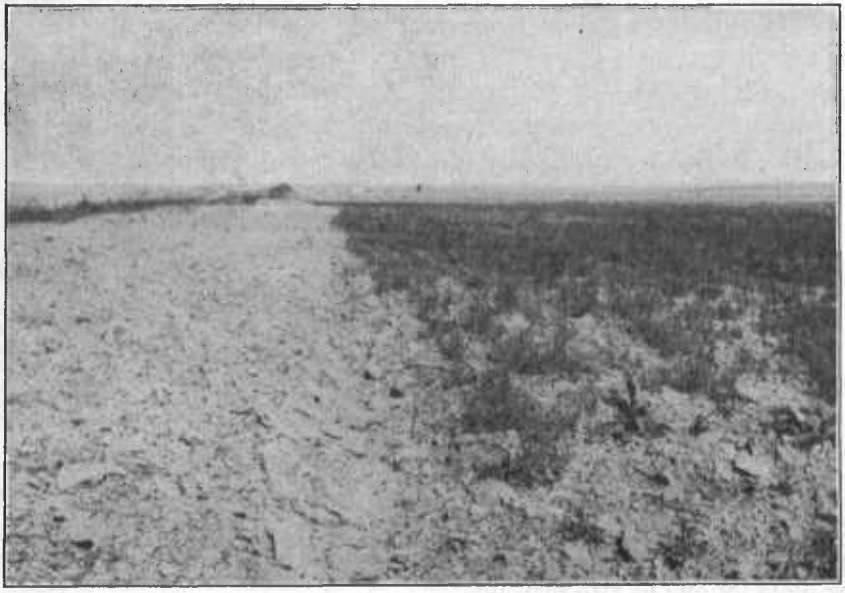

FIG. 16.—A field infested with Russian thistles which has been partially cultivated with a revolving weeder.

weeds and the crops grown, it is being increased. Which of these two processes is taking place the more rapidly is a question that will affect vitally the future productiveness of the soil. In comparing typical eastern Oregon wheat soils with like virgin soils, Bradley [1] found that the carbon or organic content of soils which had been used for raising wheat for 17 to 25 years had decreased approximately 23 per cent. In summarizing the results of a similar study of eastern Washington soils, Thatcher [2] makes the following statement:

Assuming that the observed differences between adjacent virgin soils and cultivated lands are due to the effect of the cropping of the land, it may be said

[1] Ore. Exp. Sta. Bul. No. 112.
[2] Wash. Exp. Sta. Bul. No. 105.

that these results show, in general, a significant reduction in the organic constituents of the soil by the present methods of "dry-farming" operations.

While neither of these investigations was exhaustive, they tend to show that the vegetable matter of the dry-farmed soils is decaying and disappearing faster than it is being added. If this is the case, and if this wasting of the resources of the soil is allowed to continue indefinitely, the time will undoubtedly come when crop yields will be reduced seriously and farming will be unprofitable. While more thorough cultivation of the summer fallow will result (for a time at

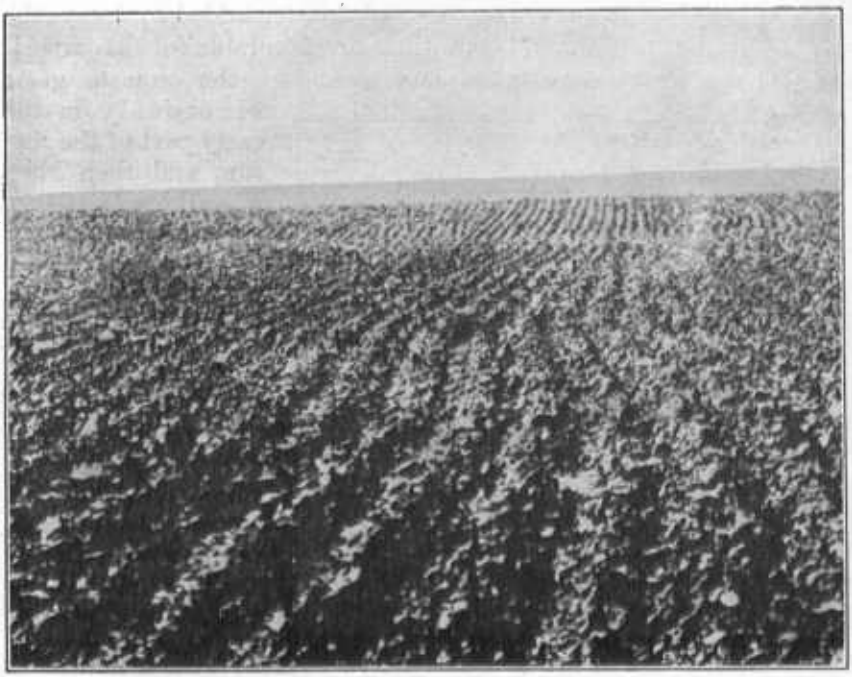

FIG. 17.—An ideal blow-soil summer fallow. The surface is ridged and covered with clods. The previous time this soil was summer-fallowed it was blown badly.

least) in increased yields, it will also cause a more rapid decay and depletion of the organic matter.

In northern Idaho and the extreme eastern portion of Washington, where the average annual rainfall ranges from 20 to 26 inches, and where the stubble plowed under is short on account of being cut with the binder, there can be little question that there has been a marked decrease in the vegetable matter of the soil. This is clearly shown by its texture. In the beginning the soils of this district were mellow and friable; now they are much more inclined to wash, run together, and break up into clods when plowed. In districts where cutting the grain with the header or combined harvester leaves practically all of the straw on the ground, it may be that vegetable matter is being

added to the soil as fast as it is decaying and disappearing. That this is the case, however, is not very probable.

VEGETABLE MATTER SHOULD BE ADDED AS FAST AS IT DECAYS.

A balance between the organic matter of the soil and the annual precipitation should be maintained, that is, vegetable matter should be added at about the rate at which it decays. Good judgment is required to maintain this balance. The addition of vegetable matter too rapidly will cause one of two things to happen. If there is not sufficient moisture to cause the vegetable matter added to decay, the soil will dry out rapidly. If conditions are favorable for decomposition, enough decay may take place to induce the crop to grow vigorously in the early part of the season, and then burn when the soil moisture becomes exhausted. If, on the other hand, the supply of vegetable matter is allowed gradually to become low through the processes of decay, a soil condition will be reached eventually that will be most difficult to correct. For this reason the problem of maintaining the vegetable matter of the soil should receive due consideration.

FIG. 18.—Burning Russian thistles in the early spring with a "fire harrow" preparatory to plowing. The fire harrow is an iron harrow that is hitched to a wagon or team by means of a long forked chain. The trash collected by the harrow is ignited and burns as the team moves forward. Note the bare ground in the foreground over which the fire harrow passed.

It is probable that more vegetable matter can be added most satisfactorily by attaching a straw spreader to the combined harvester where the grain is cut with that machine or by freely using the straw spreader where the grain is thrashed with a stationary machine. The practice of burning the stubble and weeds should be resorted to only in extreme cases, where the stubble and weeds are too heavy to be plowed under. (See fig. 18.) In districts having an annual rainfall of over 20 inches, and a clay-like subsoil (northern Idaho and parts of eastern Washington), the soil should be improved by growing leguminous crops—peas, clover, alfalfa, vetch, etc., and feeding more live stock.